Towards Liveable Streets
Urban Canyon Microclimate: An Empirical Study of Colombo

A Dissertation
Submitted to the Department of Architecture of the University of Moratuwa in partial fulfilment of the Requirements for the degree of Master of Science In Architecture

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January 2004

DECLARATION

I declare that this dissertation represents my own work, expect where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

Signed: ....

(G.R.H Silva)

ACKNOWLEDGEMENTS

This study with many complexities and difficulties completed due to the assistance, guidance and encouragement given by all of the following persons, to whom I wish to extend my heart full gratitude.

Archt. Vidura Sri Nammuni Head, Department of Architecture University of Moratuwa, for his assistance in this study.

My Coordinator Archt. Prasanna Kulathilake, Senior lecturer, Coordinator M.Sc. Dissertations, Department of Architecture for comments and criticism which encouraged me to do this study.

I am deeply indebted to my tutor Archt. Dr. Indrika Rajapaksa Lecturer Department of Architecture for her guidance, valuable comments and unreserved help given to me for the completion of this task.

Archt. Dr. Rohinton Emmanuel, Senior lecturer, Department of Architecture, for his guidance, valuable comments and unreserved help given to me.

The staff of Department of Architecture.

Mr. Chathura , Technical officer , for the given help on arranging the instruments.

Librarian and Staff, University of Moratuwa Library and University of Peradeniya Library, for the given help.

Mr.Padmasiri and his staff for their kind guidance and help on obtaining Data from the Metrological Department, Colombo.

O.I.C. 's Administration in Dehiwala, Wellawatte, Bambalapitiya, Kollupitiya and Pettah Police Stations for their assistance for possible arrangements in having the Defense clearance to carryout the Field study survey and photograph the high security zones within Colombo.

I'm also grateful to my seniors, Miss. Sathya Sajeewa and Miss. Nirosha Loyed and Mr Narain Perera for the assistance provided.

I offer my heartfelt thanks to my dearest friends Panawala ,Bashwara, Champika, and my batch mates for their valuable support rendered in completion of this task.

Last but not least I express my deepest gratitude to my dearest parents, and my Sister for their support and for always being there to take my troubles in a most loving way.

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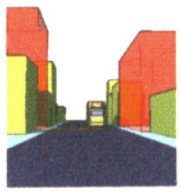
Urban Design;
Designing an Urban setting, it self can perceive as a single architectural process, not only an individual building, but also the way buildings are related each other and its three-dimensional composition represents the total image of the city. Performances of these solid–void compositions directly effected to thermal behaviour of the city.
The metropolization phenomenon at Colombo has provoked deep changes in the field of "Urban design". As well, as changes in thermal comfort levels and the energy balance, leading to an altered atmosphere of the urban area,
In Colombo, higher relative humidity values and moderation in wind speed, the daily (diurnal) variation in temperature and diminishing diurnal temperature variation would indicate a growing UHI problem. The phenomena of Urban Heat Island can create unpleasant microclimatic conditions at the pedestrian level. Pedestrian walkways are the key pubic domain of Equatorial towns and cities, where the greatest amount of human contact and interaction taken place.
Shading can create a comfortable level, avoids the direct solar radiation. Vegetation in particular tall trees can create a cooling effect, lower temperature and increase relative humidity.
The aim of this study is to investigate the effect of Orientation, built mass, tall trees with a wide foliage canopy and water bodies, on the climatic parameters, at the pedestrian level in street canyons, Colombo metropolitan. The research was conducted in either-side pedestrian walkways of two major public realms selected based on its Orientation. Each street canyon consisted with areas of deep, shallow and intermediate canyons, tall dense trees planted, street canyon relatively lacking in tall trees, directly effected water bodies etc.
One pair of walkways was located parallel to and, the other perpendicular to, the coastline. Data collected in two days of December 2003: Temperature and relative humidity, by a HOBO-HT data logger, in a well cross-ventilated radiation shield at seven feet height on each pavement,
Traverse walking along canyon, by which temperature and relative humidity were, measured using the mobile data logger at midday and night, in Dec 18th and 22nd.
The results show that during the day hours the temperature values in the canyons with vegetation were up to 2 THI values lower than those measured in the canyons without trees and it was up to 4 THI values lower in Gall face Green, where directly affected by the Ocean.
Wind speed in the canyons placed perpendicular to the coastline, was generally higher than in the canyons located parallel to the coastline and blocked by rows of building from the sea breeze, which is a characteristic of Sri Lankan western shoreline. But the effect of vortex phenomena caused by perpendicular winds, can clearly experienced in N-S oriented deep canyons,
Wind speed in canyons without trees was generally higher that in canyons with threes due to the windbreak and friction effects of the trees in the latter. The existence of shading devices above the pavements and tall dense trees in an urban environment could result in two opposite climatic effects. Shading devices moderate the air temperature and surface temperatures, preventing the direct solar radiation. In addition, trees act as moderators in both temperature and relative humidity levels towards comfortable levels.
This research shows imperative need of interferences, of climatized architectural imlpiceations in the case of street canyons and adjoined pedestrian walkways at the Colombo Metropolitan.



INTRODUCTION

INTRODUCTION

Architecture is primarily a spatial experience and it is the "unavoidable observation". Whether it is Day or Night, through out the day beholder is exposed to it. Architecture corroborate his life, take care his being. It directly addresses Physical as well as psychological comfort of its beholder.

City and Urban Design, consists of, physical forms, which can conveniently be classified in to five elements: paths, edges, districts, nodes and landmarks. It can be also defined as a place where, harmonising the balance between public domain and private domain, where the public realm, the continuity of public spaces is become crucial.

City , Urban setting it self can perceive as a single architectural entity, not only an individual building, but the way buildings are related each other and formed the total image of the city. The way people experience the city, the urban setting, and spatial relationships are been concretised a city to be perceived as a tangible architectural entity.

"Architecture and urban design should express the positive values of a society and reflect the sum of its social and economic achievement. Architects should act as coordinators on behalf of the public interest and be the advocates for a harmonious, human environment" (Hosken 1973)

So, as the work of architecture contributes, City also should address to the physical and psychological need of it's' inhabitants. If "Psychological Comfort" is the ultimate determination to succeed in the work of architecture, "Physical Comfort" could be sighted as the provider of that goal. Physical Comfort most of the time follows "Thermal Comfort". It cannot be separated. The appropriate level of "Thermal Comfort" is the essential and the major facilitator of that achievement. So "Thermal Comfort" is the key prerequisite to achieving "Psychological comfort".

The achieving of psychological comfort of the spatiality of the city, assert to be as reaching to appropriate thermal comfort level in both public and private realm and in elements ; paths, edges, districts, nodes and landmarks as a unique spatial entity.

In the perceiving of the thermal behaviour of a city it self, could be identified as a separate pattern in the composition of the classified elements of formatting a city; a clear relationship between physical spatial arrangement and thermal behaviour of the city can be identified.

Streets and Paths became the heart of physical spatial arrangement of the city and of the civic life, Specially "Streets" in Sri Lankan context. The public streets, of a country such as Sri Lanka is mostly associated with the buildings that planted along the street and its own generated activity pattern. It will incorporate all the buildings, which will open out to the street and its related activities or the usage of the space as a place.

Buildings along streets form urban street "canyons" that cause the urban surface to take on a distinctly three-dimensional character in the form of both physically as well as thermally.

According to Oke (1987) he states Urban Canyon, as, "An Urban canyon is comprised of the walls and ground (road, garden, etc.)Between two adjacent buildings as well as the canyon-air volume, which has three sides with active surfaces (walls and ground) are three open sides (ends and top)"

This three dimensional form affects the absorption of solar radiation, surface temperature, evaporation rates, storage of heat and the turbulence and wind climates of cities and can drastically alter the conditions of the near-surface atmosphere.

The Urban Canyon effect, the phenomenon is one of the major factors which push the Cities to formulate their own microclimates. Urban areas are both affected by weather and climate, and exert an influence on the local scale weather and climate. The climate in and around cities and other built up areas is altered in part due to modifications humans make to the surface of the Earth during urbanization. The Ground surfaces are typically rougher and often drier in cities, as naturally vegetated surfaces are replaced by buildings and paved streets.

People choose settings with characteristics, which they highly expected is psychologically comfortable living environments and avoid environments which they feel negatively, when preferred environments cannot be selected. They push in to adaptation or to discouraging to participate in certain activities. Therefore the understanding of urban street phenomenon is critical. It can be said, canyon microclimate of urban streets defines the physical comfort of the user and it's creation of psychological comfort of him, which generates social functions possible.

Although "life" in the equatorial tropics is largely an outdoor phenomenon, modern urban development has been failed to facilitate such living in a climatically pleasant manner.

The reflectivity of the materials used in the front facade of the buildings causes the major effects on urban canyon geometry, on thermal comfort of the street life and ultimately effected on psychological comfort of inhabitants of the city.

So, the "Urban Canyon" becomes the very important "three dimensional physical form", in the provision of determining the microclimate, thermal comfort and psychological comfort of the city and its inhabitants.
The approach then should be an attempt to identify the existing situation of the thermal behaviour in urban canyons in Colombo and make (or modify the existing situation) equatorial urban outdoors thermally comfortable and liveable.

A. Significance

Street; Path is one of the most important component in analysis of spatial elements of a city, in the experience physical perception. It is the linking and binding space, also a link between one space and another.
The public realm of a city depicts the continuity of these public spaces, and it is the most important part of Equatorial towns and cities, where the greatest amount of human contact and interaction taken place. It is the key public domain in equatorial tropics, where people gather.
"Streets and their sidewalks, the main public places of a city are its most vital organs. Think of a city and what comes to mind? It's streets. If a city's street look interesting, the city looks interesting; if they look dull, the city looks dull" (Jane Jacobs 1965:39)
Public realm of a place is a contribution of Architecture, Urban Design and the Human Being. So the liveness of Public Street becomes an essential task in urban designing. Present day, in urban designing, the considerations relating to people and the way in which they interact have tended to be neglected, especially in an urban street. Street as a public space, participates in the construction of the individuals as well as the symbolic experience of society in its diversity.
It is a common question asked by many is what the relationship between thermal comfort, and urban design. An urban designer produces design and set of guidelines for future development based on density, massing, materials, transport and etc. These elements ultimately consume energy in various forms to carry out their function. If each and every single designer produce a design without considering the natural forces ,not only the consumption of energy and recourses

will be utterly inefficient .but also environmental degradation will be very high due to the emission of pollution and wastes. This phenomenon that causes by each building ended with lot of environmental problems in the end in macro situation; Urban Heat Island In Sri Lanka, Colombo as the major commercial and administrative centre, the built to unbuilt ratio of the city fabric is going to be very low in near future, means that increases the surfaces area of heat capturing and reflecting within the city. The totally glazed facade results the air-conditioning of the building. Although air-conditioned interior of these glass capsules is comfortable to carry out whatever the work in efficiently, it releases lot of heat to the exterior of it's own generated, through AC plants and as radiant heat which reflected by the tinted facades. All this heat releases in to the public streets without a control, admit will directly effected to the city life with combination of thermal effects occurs by width of the Road , building height, wind pattern and building materials used in the street facades. This effect becomes extremely worse in a deep Urban Canyon.
The effects of this phenomenon is directly pushing the liveable public spaces, in to dead spaces, and ultimately towards a dead city.

B. Objectives

The intention of the study is to identify the relationship between Street Form and thermal behaviour of urban canyon microclimate of Colombo which based on case study and observation. Also to understand the three-dimensional patterns of public space which directly affects the thermal behaviour of the street enclosure. Study is attempted to guide architectural responsiveness to the environment with reference to a basis, which leads to create a liveable city, through a liveable Urban Canyon. Finally the analysis will proceed into the potentials to rejuvenate life in streets.

Therefore the study aims to focus on:

- Historical development of the physical structure as well as the activity pattern which had been developed over a period of time and causes of selected Urban Canyons.
- To study and analyze activity patterns of selected existing urban canyons and thermal behaviour of the street enclosure, it will try to introduce a basis which includes patterns to create a liveable city.

- For the analysis purpose of the causes which govern the life patterns of the public places especially in urban canyon, it will introduce qualities of a responsiveness of the built environment to create a liveable place.
- Using the fundamental basis of the public realm of a place is evaluated and this proceeds into understand the relationship between the analysis and rejuvenating street life, and the quality of the life in a liveable city.
- On-site data collection and subsequent thermal evaluation / comparison of the spaces within the street, which allow for the selection of focused urban spatial patterns.

The conclusion will provide the analysis and enabling potentials to use the urban street as the principle mode of public realm in the context of Sri Lanka by achieving a physically and psychologically comfortable public living standards towards "liveable streets" , through a higher level of thermal comfort .

Man- environment interaction in an urban street, how it's really experienced and comprehended, and the effects of such values and the accessibility of the street space is also explored.

C. Hypothesis

- Dense areas of vegetation and water bodies influence climatic parameters of surrounding areas.
- Shading or shaded areas of the urban canyons have a distinct positive bearing on the thermal comfort of its beholder.
- The orientation, sky view factor and the ratio of building height to the width of the canyon considered can be consciously modified in order to achieve the shade.
- Increased height to width ratio of the built mass increases the level of thermal comfort.

D. Method of the Study

Method of study is a Case Study based approach. The study evaluates the effect of the building surfaces, built mass on shading and thereby the thermal comfort of urban public space in an empirical manner.

The case studies were selected by an investigation and considering following parameters of the urban structure in Colombo

- Orientation of Canyon , Symmetric / Asymmetric Canyon, width to Height ratio
- Canyons with special Features: Water Bodies / Vegetation
- Sky View Factor
- Air Flow Characteristics: Perpendicular wind / Parallel Wind / Oblique Wind & Roof Type (Flat / Pitched / Gable)
- Zoning of Activities: Commercial / Residential / Mixed Development
- Vehicular Movement: Heavy / Intermediate / Low Traffic Flow
- Boundary Layer Characteristics :Materials Used in the Street envelope
- Activity Pattern: which is functioning in the Urban Canyon
- Shadow-Umbrella Phenomenon: Shaded areas caused by buildings and exposed time duration, Existing situation and importance and the value remaining regarding the form of the street, According to their particular location, and the permeability of the place.

A typology of urban canyon developed on the basis of above parameters.

Derive a structure to select the case studies based on the criticality of thermal behaviour which is directly address the psychological and physical comfort of the beholder and their activities happening within the "street canyon". In the selected streets in urban canyons in the settings of which encompasses varying typologies of public space relative to the main focus of "urban canyon", and is studied for its bio climatic patterns, onsite measurements on temperature (dry bulb air temperature ,wind speed and direction, Humidity, Physical form mapping, behaviour study , photographic survey, graphical survey and observation by the researcher. is also carried out specially considering three-dimensional form , activity pattern, and permeability of the place.

On-site data collection and subsequent thermal evaluation/compression of the spaces within the selected urban canyons, which allow for the selection of focused urban spatial patterns. The present thermal behaviour of the selected sections of the street and envisioned modifications, are to be proposing in generating variations of THI index in the form of urban design implications.

E. Scope and Limitations

Public realm of a city can be a collection of spaces as streets, squares, boulevards, gardens etc. but the study here mainly focused on to the urban streets, the Urban Canyon. There are a range of factors to consider in evaluating the Thermal Comfort values of a given situation, which is directly influenced the behavioural pattern; such as street patterns, spatial pattern of city function by it self, and way each of these are relate each other are also to be consider. But those aspects will not be considered is the study. It is beyond the scope of study.

Aspect here it would examine the human behaviour and directly related comfortable factors in-depth, in relation to the urban street-Canyon environment and the way people behave within that architectural entity. Yet it explored into, the physical form, and the formal design aspects of a place. Therefore the study stresses on the behaviour of thermal effect on an Urban Canyon and its effects on the liveable street life, related activity pattern (i.e.; in terms of community life and people).

A data range conveying a longer time period about several years, within an year, within a day both in day and night, rainy seasons , windy seasons should consider in order to derive a concretise decisions and would result in the formation of more accurate trends in patterns considered. The limitation of the data range being restricted to a single day, both day and night of the years.